INTI International College Penang
LAUREATE INTERNATIONAL UNIVERSITIES

**FINAL**
Examination Paper

(COVER PAGE)

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| Session | : | **August 2015** |
| Programme | : | Diploma in Electrical and Electronic Engineering (DEEI) |
| Course | : | **EEE2113: Electric Power Systems and Machines** |
| Date of Examination | : | 11th December 2015 (Friday) |
| Time | : | 11:00am – 1:00pm Reading Time : Nil |
| Duration | : | 2 Hours |
| Special Instructions | : | |

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

**IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL**

Materials permitted :

Non-Programmable Scientific Calculator

Materials provided :

Nil

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| Examiner(s) | : | **Mr. Ken Kong Seng Kuok** |
| Moderator | : | Dr. Cheah Kean Seng |

*This paper consists of 6 printed pages, including the cover page.*

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE 2113: ELECTRIC POWER SYSTEMS AND MACHINES
FINAL EXAMINATIONS: AUGUST 2015 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

**Question 1**

(a) Define interpoles. (2 marks)
State the main function of interpoles in a D.C. Machine. (3 marks)

(b) What are the minimum number of interpoles needed in a 2-pole D.C. Machine? State your reason to support your answer. (2 marks) (3 marks)

(c) Consider the following wiring arrangement for a DC machine.

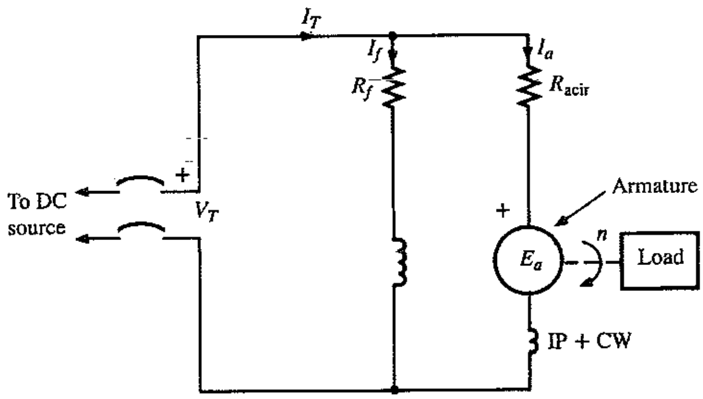


Figure 1(c): D.C. machine wiring arrangement

(i) What is the name of the D.C. machine that this wiring arrangement usually refer to? Please list two characteristics of this type of D.C. machine. (3 marks)

(ii) The DC source is supplying 430 V. The motor rated output is 1 kW. The shunt field wiring resistance is 180 Ω. The armature wiring resistance breakdown is as follow: armature winding: 0.2Ω; interpole winding: 0.1Ω and compensating winding: 0.5 Ω.
What is the rated counter-e.m.f. generated by the motor if the rotational losses are 3% of rated output power? Neglect the voltage drop across the brush in the calculation. (5 marks)

(iii) At rated load, the motor is turning at rated speed of 1603 rpm. What is the value of torque experienced by the load? (2 marks)

(iv) Find the input power to the motor if the voltage drop across the brush is 0.5V. What is the efficiency of the motor? (5 marks)

**Question 2**

(a) Describe the operation of LIMPET, a wave energy converter installed on the Scottish island of Islay.
(5 marks)

(b) List 3 advantages and disadvantages of wind turbine.
(6 marks)

(c) A wind power generator is built with the following specification:

Blade length: 45 m
Blade number: 3
Height: 200 m

The average wind speed at this area is 35 miles/hour, where 1 m/s is equivalent to 2.237 miles/hour. The air density is taken as 1.225 kg/m$^3$. The overall efficiency is 30%.

(i) Find out the power output of the generator. (7 marks)
(ii) What is the optimum revolution speed for the turbine blades in r.p.m.? (7 marks)

**Question 3**

(a) The transmission line can be represented with suitable 2-port network model. What are conditions in terms of length and voltage magnitude for using the following?

(i) short line model (2 marks)
(ii) medium line model (2 marks)
(iii) long line model (2 marks)

(b) A 50-Hz 3-phase transmission line has the following constants:

$R = 10\ \Omega$ / phase
Inductive reactance = $20\ \Omega$ / phase
Capacitive susceptance = $4 \times 10^{-4}$ mho / phase

Calculate the following when the line used in supplying a balanced load of 10,000 kW at 66-kV, 0.8 p.f. lagging:

(i) Sending end voltage (9 marks)
(ii) Line current (5 marks)
(iii) Power factor at the sending end (2 marks)
(iv) Efficiency of transmission (3 marks)

**Question 4**

(a) A 66 kV line is fed through an 11/66 kV step-up transformer from an 11 kV supply. At the load end of the line the voltage is step-down by another transformer of nominal ratio 66/11 kV. The total impedance of the line and transformers at 66 kV is 12.5 + j33 Ω. Both transformers are equipped with tap-changing facilities which are arranged so that the product of the two off-nominal settings is unity. If the load on the system is 50 MW at 0.8 pf lagging, calculate the settings of the tap changer required to maintain the voltage of the load busbar at 11 kV. Use the base power of 50 MVA.

(13 marks)

(b) A single core cable for use on 11 kV, 50 Hz system has conductor area of 0.645 $cm^2$ and internal diameter of sheath is 2.18 cm. The permittivity of the dielectric used in the cable is 3.5. $\varepsilon_o$ is $8.854 \times 10^{-12}$.

(i) Determine the maximum electrostatic stress in the cable. (3 marks)
(ii) Determine the minimum electrostatic stress in the cable. (3 marks)
(iii) Determine the capacitance of the cable per km. (3 marks)
(iv) Find the corresponding charging current. (3 marks)

**Question 5**

The variable operating cost of three generating units are given by

$F_1 = 655 + 6.8P_1 + 0.007P_1^2$ RM/hr
$F_2 = 695 + 6.5P_2 + 0.006P_2^2$ RM/hr
$F_3 = 755 + 6.0P_3 + 0.005P_3^2$ RM/hr

If the total load demand varies from 125, 230 and 340 MW, determine the

(i) incremental operation cost at each demand level, (8 marks)
(ii) power output of each unit at the mentioned demand level, (10 marks)
(iii) total operating cost, $F_T$, that minimize $F_T$ for the above-mentioned load demands. (7 marks)

**Question 6**

(a) Explain the following tariff:

(i) Flat rate tariff (5 marks)
(ii) Two part tariff (5 marks)
(iii) Sliding scale tariff (5 marks)

(b) An electric supply company supplies a maximum peak load of 230 kW and load factor is 30%. Find the total cost of energy consumption per annum based on the following two tariffs offered:

(i) RM 120 per kW of maximum demand plus 30 sen per kWh (5 marks)
(ii) A flat rate of 35 sen per kWh (5 marks)

**~The End~**

Summary of Equations:

D.C. Machines

$V_T = E_a + I_a R_{acir}$ (motor voltage and emf relationship)

$E_a = V_T + I_a R_{acir}$ (generator voltage and emf relationship)

$P_{mech} = V_T I_a - I_a^2 R_{acir}$ (mechanical power)

$T_D = \frac{9.55\, P_{mech}}{n}$ (developed torque)

$\eta = \frac{P_{out}}{P_{input}}$ (machine efficiency)

Alternative Energy Sources

$P_w = \frac{1}{2}\rho A v^3 \eta$ (wind power)

$TSR = \frac{4\pi}{n}$ (tip speed ratio)

$E_{potential} = mgH$ (potential energy in water)

Power (kW) approximately = 9.81 Q H ρ (power in water)

Avogadro's constant = $6.023 \times 10^{23}$ per mole

1 eV = $1.602 \times 10^{-19}$ Watt-sec (Joules)

$\eta = P_m / (E \times A_c)$ (solar panel efficiency)

$P = (\rho g^2/64\pi)H^2_{m0}T_e$ (wave power)

Load Study

$$average\ demand(W) = \frac{total\ energy\ demand\ (W\cdot hr)}{total\ time\ (hr)}$$

$$load\ factor = \frac{average\ demand(W)}{maximum\ demand(W)}$$

$$demand\ factor = \frac{maximum\ demand(W)}{total\ connected\ load(W)}$$

$$diversity\ factor = \frac{sum\ of\ individual\ maximum\ demand(W)}{maximum\ demand\ on\ power\ station\ (W)}$$

$$plant\ capacity\ factor(plant\ factor) = \frac{average\ demand\ on\ the\ plant(W)}{total\ plant\ capacity(W)}$$

$$plant\ use\ factor(utilization\ factor) = \frac{actual\ energy\ produced(W\cdot hr)}{plant\ capacity(W)\times total\ time(hr)}$$

Per Unit System

$$Z_{pu(new)} = Z_{pu(old)} \times \left(\frac{V_{b(old)}}{V_{b(new)}}\right)^2 \times \frac{VA_{base(new)}}{VA_{base(old)}}$$

(changing per unit value from one base reference to another base reference)

Transmission Line Model

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$ (short line model)

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1+\frac{YZ}{2} & Z \\ Y+\frac{Y^2Z}{4} & 1+\frac{YZ}{2} \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$ (π model)

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1+\frac{YZ}{2} & Z+\frac{YZ^2}{4} \\ Y & 1+\frac{YZ}{2} \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$ (T model)

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} \cosh\gamma l & Z_C \sinh\gamma l \\ \frac{1}{Z_C}\sinh\gamma l & \cosh\gamma l \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$ (long, rigorous model)

Transmission Line Parameters

$L = 2 \times 10^{-7} \ln (GMD/GMR_L)$ H/m (inductance)

$C = 2 \pi\varepsilon / \ln (GMD/GMR_C)$ F/m (capacitance)

Cable Grading

$g = \frac{V12}{x \ln\left(\frac{D2}{D1}\right)}$ (dielectric stress)

$V_n = g_{max}\, r_{n-1} \ln\left(\frac{r_n}{r_{n-1}}\right)$ ; n = 1, 2, 3… (voltage distribution)

Optimal Dispatch

$\lambda = \frac{P_D + \sum_{i=1}^{n} \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^{n} \frac{1}{2\gamma_i}}$ (incremental cost)

$P_i = \frac{\lambda - \beta_i}{2\gamma_i}$ (power output)

Voltage Control Method

$t_s = \sqrt{\frac{\frac{|V_1|}{|V_2|}}{1 - \frac{R\ P\ +X\ Q}{|V_1||V_2|}}}$ (tap-changing transformer adjustment ratio)